YAKEEN

Lecture - 3

SOLUTIONS

By

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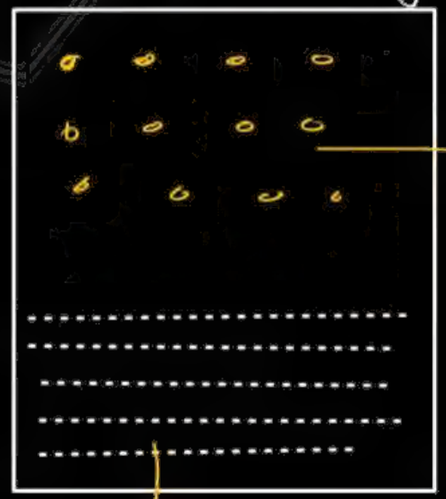
TODAY'S GOAL

RAOULT'S LAW

IDEAL SOLUTION

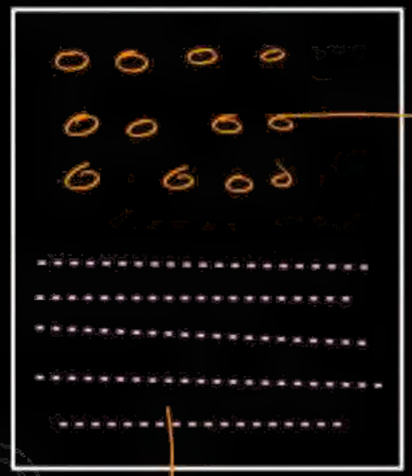
RAOULT'S LAW

V.P of any Component in solution is equal to product of V.P of that Component in pure form & mole fraction of that Component in solution



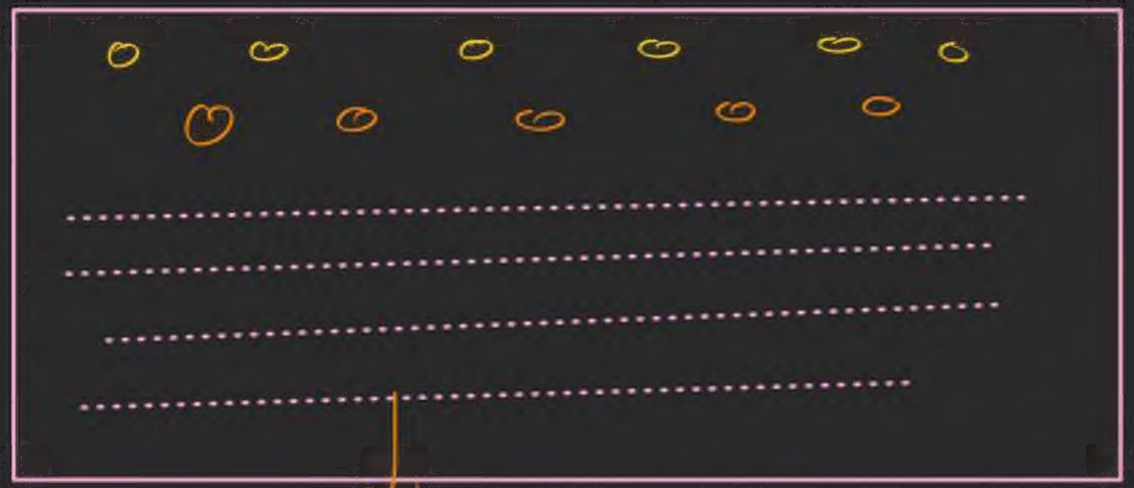
P^0_A = V.P of A in Pure form

Volatile Solvent (A)



P^0_B = V.P of B in pure form

Volatile Solute B



Solution

P_A = V.P. of A in Solution

P_B = V.P. of B in Solution

$$P_A = P_A^\circ \chi_A$$

$$P_B = P_B^\circ \chi_B$$

RAOULT'S LAW FOR VOLATILE SOLUTE

Volatile Solvent (A)

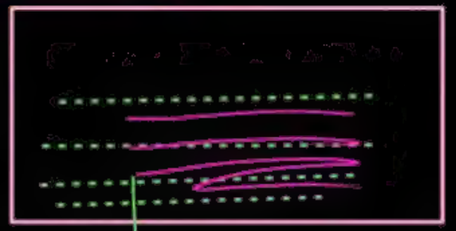
$P_A^\circ \neq 0$

+

Solute (B)
Volatile

$P_B^\circ \neq 0$

=



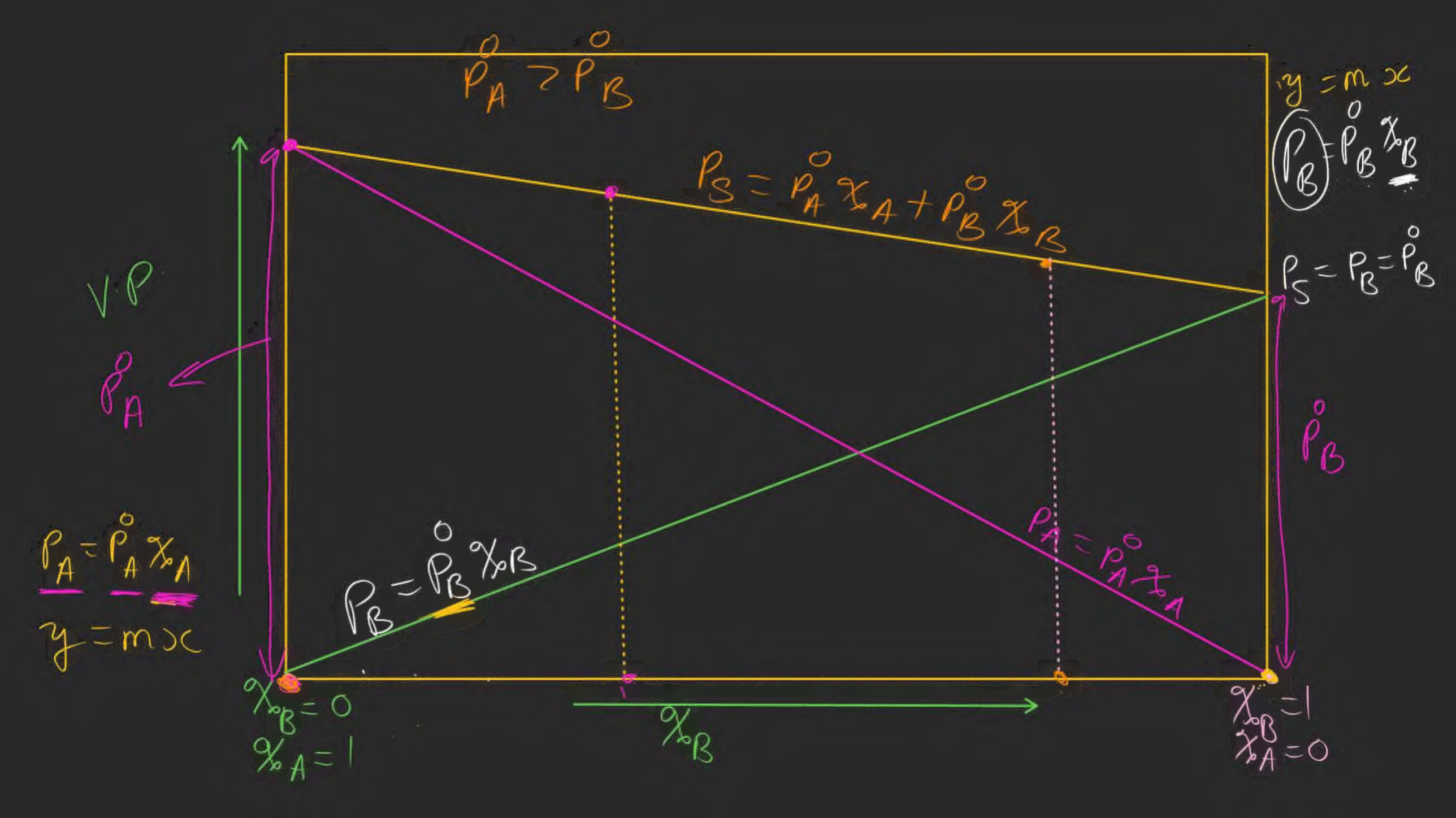
Solution

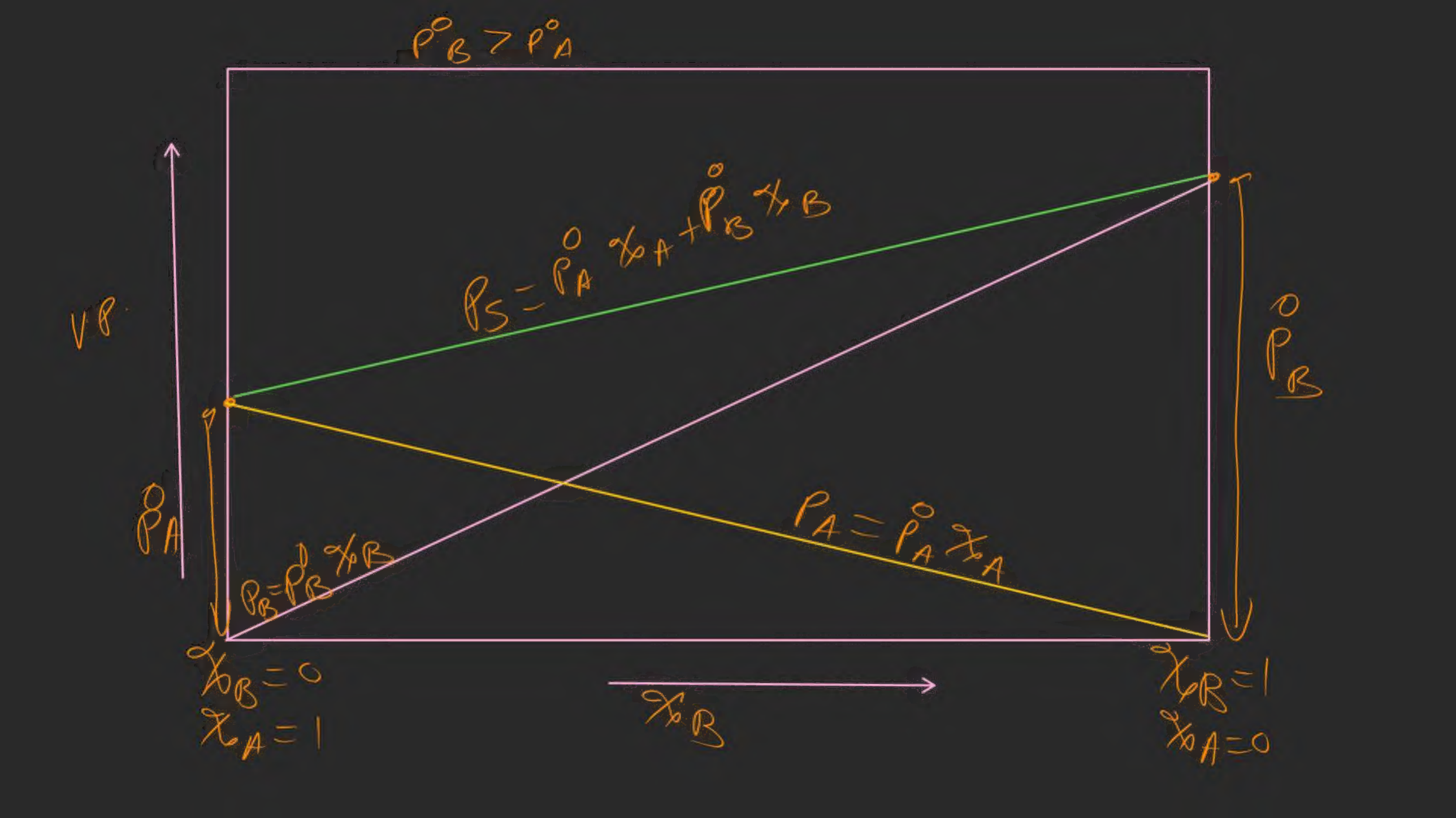
$P_A = P_A^\circ \chi_A$

$P_B = P_B^\circ \chi_B$

$$P_S = P_A^\circ \chi_A + P_B^\circ \chi_B$$

P_S → V.P. of solution


$P_A^\circ > P_B^\circ$
$y = mx$
$P_B = P_B^\circ x_B$
$P_S = P_A^\circ x_A + P_B^\circ x_B$
$P_S = P_B = P_B^\circ$
V.P
P_A
P_B°
$P_A = P_A^\circ x_A$
$P_B = P_B^\circ x_B$
$P_A = P_A^\circ x_A$
$y = mx$
$x_B = 0$
$x_A = 1$
x_B
$x_B = 1$
$x_A = 0$


$P^\circ_B > P^\circ_A$
VP
$P_S = P^\circ_A \chi_A + P^\circ_B \chi_B$
P°_B
P°_A
$P_A = P^\circ_A \chi_A$
$P_B = P^\circ_B \chi_B$
$\chi_B = 0$
$\chi_A = 1$
χ_B
$\chi_B = 1$
$\chi_A = 0$

$$P_S = P_A^\circ \chi_{oA} + P_B^\circ \chi_{oB}$$

$\chi_{oB} = 0, \quad \chi_{oA} = 1$

$$P_S = P_A^\circ$$

$\chi_{oB} = 1, \quad \chi_{oA} = 0$

$$P_S = P_B^\circ$$

RAOULT'S LAW FOR NON-VOLATILE SOLUTE

Volatile Solvent

$P_A^\circ \neq 0$

Non-Volatile Solute

$P_B^\circ = 0$

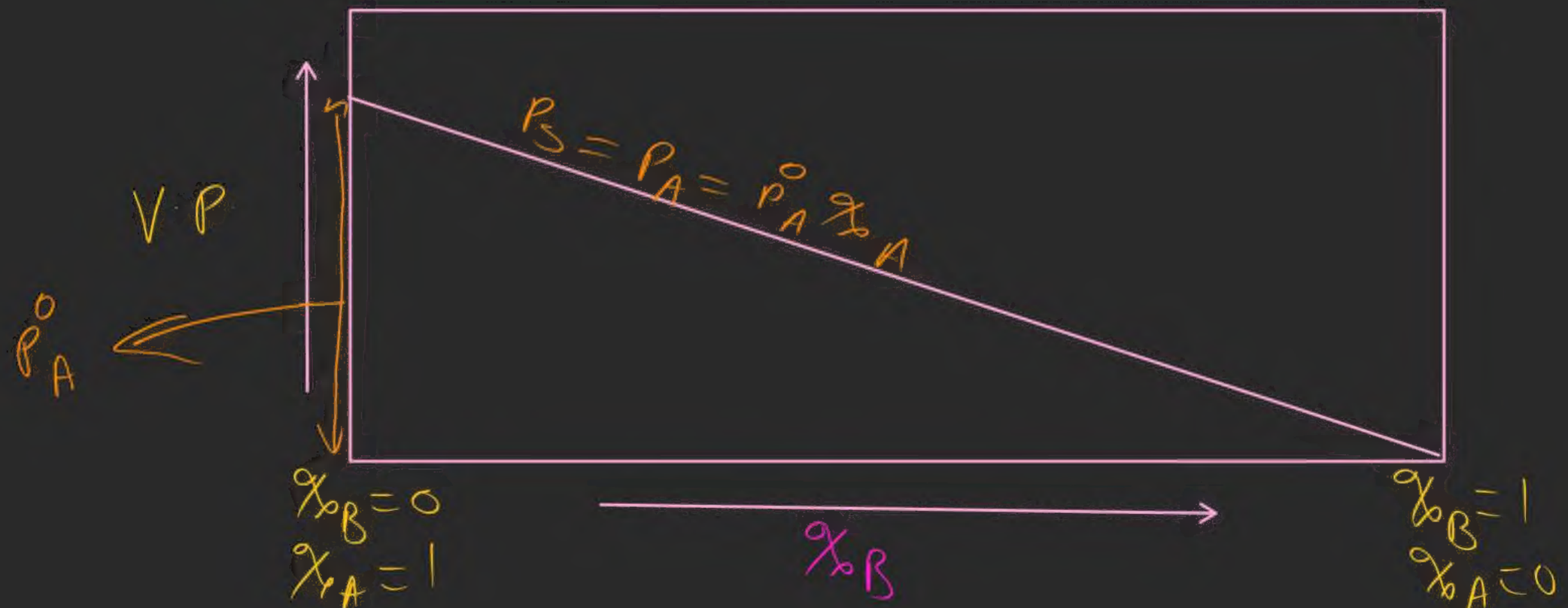
Solution

$P_S = P_A^\circ \chi_A + P_B^\circ \chi_B$

$$P_S = P_A^\circ \chi_A = P_A$$ (as $P_B^\circ = 0$)

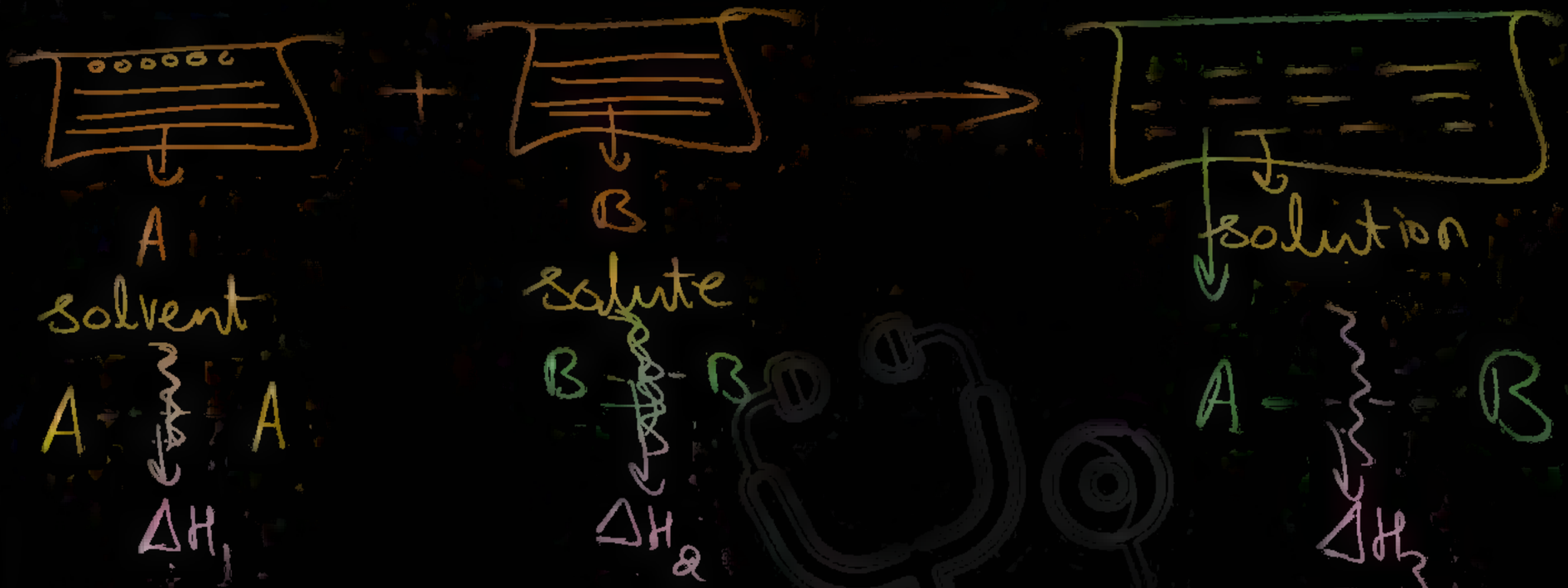
↓

Raoult's law for non-volatile solute



IDEAL SOLUTION

① Solution which obey Raoult's law at all temperature & Pressure

② 

When Forces of Interaction b/w

Solvent - - solvent or Solute - - solute are

Similar to that of Solution (Solvent — Solute)

PROPERTIES OF IDEAL SOLUTION

(a)

$$P_S = P_A^\circ \chi_{oA} + P_B^\circ \chi_{oB}$$

$$P_S = P_A^\circ (1 - \chi_{oB}) + P_B^\circ \chi_{oB}$$

$$P_S = P_A^\circ - P_A^\circ \chi_{oB} + P_B^\circ \chi_{oB}$$

$$\boxed{P_S = (P_B^\circ - P_A^\circ)\chi_{oB} + P_A^\circ}$$

$(\chi_{oA} + \chi_{oB} = 1)$

$\chi_{oA} = (1 - \chi_{oB})$

$\chi_{oB} = 1 - \chi_{oA}$

(b) $\Delta H_{mixing} = 0$

(c) $\Delta V_{mixing} = 0$

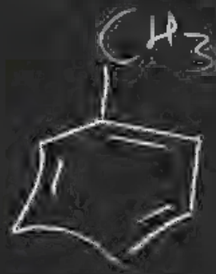
(d) $\Delta S_{mixing} = (+)ve$

(e) $\Delta G_{mixing} = (-)ve$

→ for every spontaneous reaction

for ex - same Homologous series

(a) n-Heptane + n-Octane

(b)  + 

Benzene + Toluene

(c) C_2H_5Br + $CH_3CH_2CH_2Br$

(d) C_2H_5Br + C_2H_5I

MOLE FRACTION OF ANY COMPONENT IN VAPOUR PHASE

Y_A = Mole fraction of A in Vapour phase

Using D P P (Dalton's law of Partial Pressure)

$$P_A = Y_A P_T \quad (P_T = P_S)$$

$$P_A = Y_A P_S$$

$$Y_A = \frac{P_A}{P_S}$$

$$Y_A = \frac{P^\circ_A x_A}{P^\circ_A x_A + P^\circ_B x_B}$$

$$P_B = Y_B P_S$$

$$Y_B = \frac{P_B}{P_S}$$

$$Y_B = \frac{P^\circ_B x_B}{P^\circ_A x_A + P^\circ_B x_B}$$

If $x_A = x_B$ & $P_A^\circ > P_B^\circ$

$\Rightarrow Y_A > Y_B$

& also $Y_A > x_A$

$\frac{P_T}{P_S} = 1$

$x_A + x_B = 1$

$Y_A + Y_B = 1$

$\frac{P_A}{P_S} + \frac{P_B}{P_S} = 1$

$\frac{P_A + P_B}{P_S} = 1$

Benzene and toluene form a ideal solution and V.P. of pure benzene and toluene are 160 mm of Hg and 60 mm of Hg. Calculate partial pressure of benzene and toluene and total pressure also

(a) Containing equal mass of both benzene and toluene

(b) Containing equal molecules of both benzene and toluene

(c) Containing 1 mole of benzene and 4 moles of toluene

(d) Also calculate mole fraction of Benzene and toluene in vapour phase if equal moles of benzene and toluene mixed

Molar mass of
Benzene = 78 g
Toluene = 92 g

A → Toluene
B → Benzene

$P_S = P_A^\circ \chi_A + P_B^\circ \chi_B$

$P_B^\circ = 160 \text{ mm of Hg}$

$P_A^\circ = 60 \text{ mm of Hg}$

$P_A = ?$
$P_B = ?$
$P_S = ?$

Let mass of Benzene & Toluene = $78 \times 92 = 7176$

$$n_B = \frac{7176}{78} = 92$$

$$n_T = \frac{7176}{92} = 78$$

$$\chi_A = \frac{78}{78+92} = \frac{78}{170} = 0.46$$

$$\chi_B = 1 - \chi_A = 0.54$$

$$P_A = P_A^{\circ} \chi_A$$

$$P_A = 60 \times 0.46$$

$$P_B = P_B^{\circ} \chi_B$$

$$P_B = 160 \times 0.54$$

$$P_S = P_A + P_B$$

$$P_S = 60 \times 0.46 + 160 \times 0.54 =$$

$$= 27.6 + 86.4 = 114$$

(b) Let molecules of Benzene & Toluene = N_A

$$n_A = \frac{N_A}{N_A} = 1 \quad | \quad n_B = \frac{N_A}{N_A} = 1$$

$$X_A = \frac{n_A}{n_A + n_B} = \frac{1}{2} = 0.5 \quad | \quad X_B = 0.5$$

$P_A = P_A^\circ \chi_A = 60 \times \frac{1}{2} = 30 \text{ mm of Hg}$

$P_B = P_B^\circ \chi_B = 160 \times \frac{1}{2} = 80 \text{ mm of Hg}$

$P_S = P_A^\circ \chi_A + P_B^\circ \chi_B$

$= 30 + 80 = 110 \text{ mm of Hg}$

(C) $n_B = 1$

$n_A = 4$

$\chi_A = \frac{4}{5} = 0.8$

$\chi_B = 1 - \chi_A = 0.2$

$P_A = 60 \times 0.8 = 48 \text{ mm of Hg}$

$P_B = 160 \times 0.2 = 32 \text{ mm of Hg}$

$P_S = 48 + 32 = 80 \text{ mm of Hg}$

(d) $Y_A = \frac{P_A^0 \chi_A}{P_S} = \frac{3\phi}{11\phi} = \frac{3}{11}$

$Y_B = \frac{P_B^0 \chi_B}{P_S} = \frac{8\phi}{11\phi} = \frac{8}{11}$

$n_A = n_B$

$\chi_A = \chi_B = \frac{1}{2}$

The vapour pressure of two liquids P and Q are 80 and 60 torr respectively. The total vapour pressure of solution obtained by mixing 3 moles of P and 2 moles of Q would be [AIIMS 2012]

(a) 140 torr
(b) 20 torr
(c) 68 torr
(d) 72 torr

A → A, B → B

$P_A^0 = 80$

$P_B^0 = 60$

$P_S =$

$n_A = 3$

$n_B = 2$

$\chi_A = \frac{3}{5} = 0.6$

$\chi_B = \frac{2}{5} = 0.4$

$P_S = P_A^0 \chi_A + P_B^0 \chi_B$

$= 80 \times \frac{3}{5} + 60 \times \frac{2}{5}$

$= 48 + 24 = 72$ torr

p_A° and p_B° are the vapour pressure of pure liquid components A and B respectively of an ideal binary solution. If χ_A represents the mole fraction of component A, the total pressure of the solution will be [CBSE AIPMT]

(a) $p_A^\circ + \chi_A (p_B^\circ - p_A^\circ)$

(b) $p_A^\circ + \chi_A (p_A^\circ - p_B^\circ)$

(c) $p_B^\circ + \chi_A (p_B^\circ - p_A^\circ)$

(d) $p_B^\circ + \chi_A (p_A^\circ - p_B^\circ)$

$$P_S = P_A^\circ \chi_A + P_B^\circ (1 - \chi_A)$$

$$P_S = P_A^\circ \chi_A + P_B^\circ - P_B^\circ \chi_A$$

$$\boxed{P_S = (P_A^\circ - P_B^\circ)\chi_A + P_B^\circ}$$

For an ideal solution, the correct option is [NEET-2019]

(a) $\Delta_{mix} S = 0$ at constant T and P

(b) $\Delta_{mix} V \neq 0$ at constant T and P

(c) $\Delta_{mix} H = 0$ at constant T and P

(d) $\Delta_{mix} G = 0$ at constant T and

Which one of the following is incorrect for ideal solution?

[NEET-Phase-2-2016]

(a) $\Delta H_{mix} = 0$

(b) $\Delta U_{mix} = 0$

(c) $\Delta P = P_{observed} - P_{calculated\ by\ Raoult's\ law} = 0$

(d) $\Delta G_{mix} = 0$ → wrong

$\Delta P = P_{observed} - P_{calculated\ by\ Raoult's\ law} = 0$

Which one is not equal to zero for an ideal solution? [AIPMT-2015]

(a) $\Delta P = P_{observed} - P_{Raoult}$

(b) ΔH_{mix}

(c) ΔS_{mix}

(d) ΔV_{mix}

Which of the following statements about the composition of the vapour over an ideal 1 : 1 molar mixture of benzene and toluene is correct? Assume that the temperature is constant at 25°C (Given, Vapour Pressure Data at 25°C, benzene = 12.8 kPa, toluene = 3.85 kPa) [NEET-2016]

(a) Not enough information is given to make a prediction

(b) The vapour will contain a higher percentage of benzene

(c) The vapour will contain a higher percentage of toluene

(d) The vapour will contain equal amounts of benzene and toluene

$n_A = n_B \Rightarrow \chi_A = \chi_B = \frac{1}{2}$

χ_A ↓ Toluene, χ_B ↓ Benzene

$Y_A = ?$

$Y_B = ?$

$P^\circ_B = 12.8\ kPa$

$P^\circ_A = 3.85\ kPa$

as $P^{\circ}_{B} > P^{\circ}_{A}$ ($\chi_A = \%_B$)

$Y_B > Y_A$

Benzene

Toluene

At a given temperature, the vapour pressure in mm of Hg of Hg of a solution of two volatile liquids A and B is given by equation $P = 120 - 80\ \chi_B$

Calculate V.P. of pure A and B at same temperature

Ans

$P_S = 120 - 80\,\chi_B$

$P_S = -80\,\chi_B + 120$

$P_S = (P_B^\circ - P_A^\circ)\chi_B + P_A^\circ$

$P_B^\circ - P_A^\circ = -80$

$P_A^\circ = 120$

$120 - P_B^\circ = -80 \Rightarrow P_B^\circ = 40$

Two liquids A and B form an Ideal solution at 300 K the V.P. of solution having 1 mole of A and 3 mole of B is 550 mm of Hg. At same temperature if 1 more mole of B is added to solution, V.P. of solution increases by 10 mm of Hg. Determine V.P. of A and B in pure state.

Ans

$P_S = 550 \text{ mm of Hg}$

$n_A = 1$ $\quad P_A^0 = x \text{ mm of Hg}$

$n_B = 3$ $\quad P_B^0 = y \text{ mm of Hg}$

$\chi_A = \frac{1}{4} = 0.25$ $\quad \chi_B = \frac{3}{4} = 0.75$

$n_B = 4$ $\quad P_S = 560 \text{ mm of Hg}$

$n_A = 1$

$\chi_A = \frac{1}{5} = 0.2$

$\chi_B = \frac{4}{5} = 0.8$

$$P_A^0 \chi_A + P_B^0 \chi_B = P_S$$

$$0.2 \times [0.25x + 0.75y = 550$$

$$0.25 \times [0.2x + 0.8y = 560$$

$$0.15y = 110$$

$$\pm 0.2y = \pm 140$$

$$\pm 0.05y = \pm 30$$

$$y = \frac{30}{0.05}$$

$$y = \frac{30}{5} \times 100 = 600$$

$$x = 400$$

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The V.P. of pure liquids A and B are 450 and 700 mm of Hg. Find out composition of liquid mixture if total vapour pressure is 600 mm of Hg. Find composition of vapour phase

Ans

$P^\circ_A = 450$

$P^\circ_B = 700$

$P_S = 600$

$P_S = (P^\circ_B - P^\circ_A)\chi_B + P^\circ_A$

$\chi_A = ?$

$\chi_B = ?$

$600 = 250\,\chi_B + 450$

$150 = 250\,\chi_B$

$\chi_B = \frac{15}{25} = \frac{3}{5}$

$$\chi_{oA} = 1 - \chi_{oB} = 1 - \frac{3}{5} = \frac{2}{5}$$

$$Y_A = \frac{P_A^{\circ}\,\chi_A}{P_S} = \frac{450 \times 0.2}{600} = \frac{9\phi}{60\phi} = \frac{9}{60}$$

$$Y_B = 1 - Y_A = 1 - \frac{9}{60} = \frac{51}{60}$$


thanks
for watching
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